ProtoDUNE commissioning: Beginning the noise campaign

ProtoDUNE DRA

David Adams
BNL
September 19, 2018

Introduction

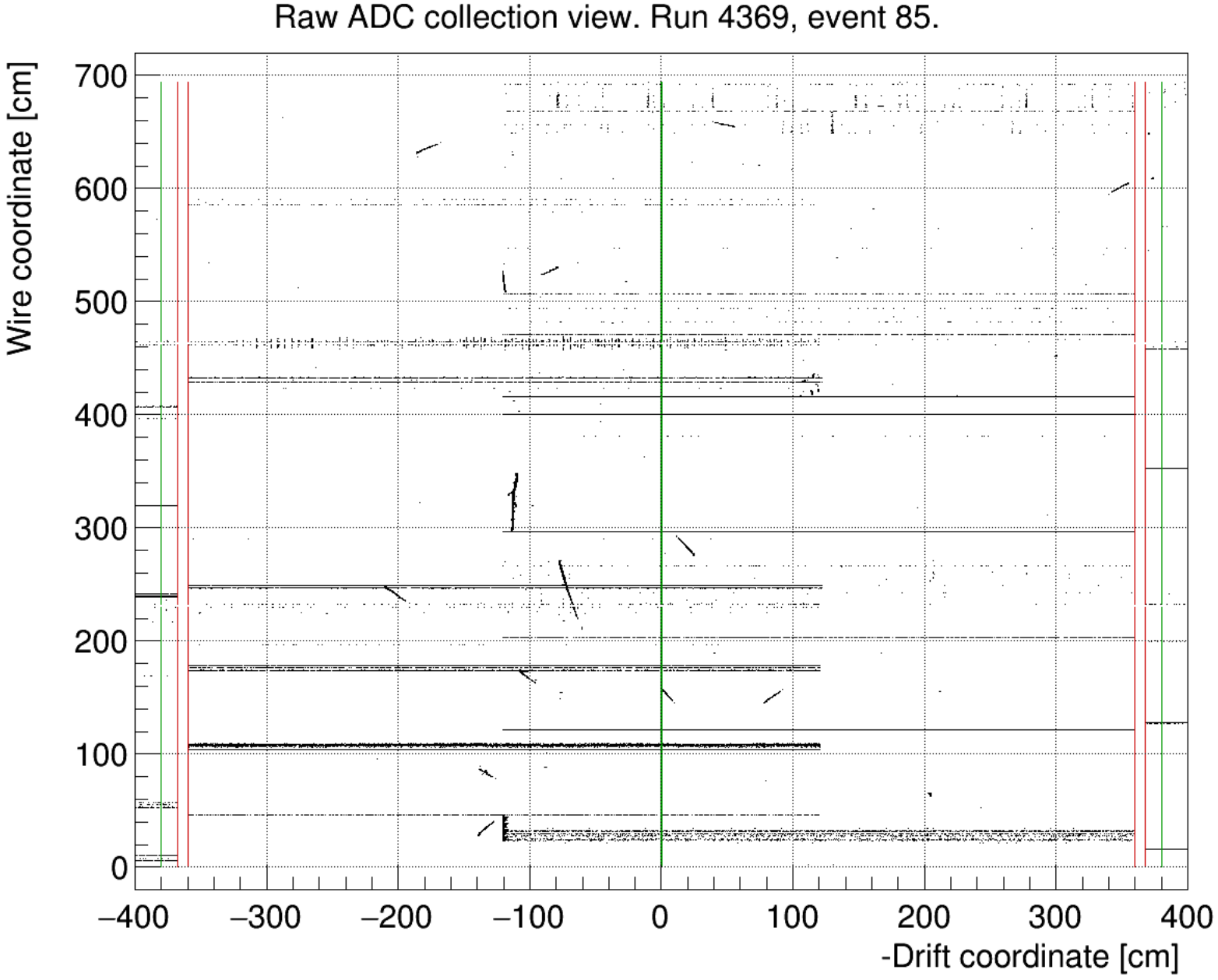
The protoDUNE detector is being commissioned

- Filled with Lar
- HV run up past 170 kV
  - Goal is 180 kV (500 V/cm)
  - Voltage instabilities being addressed
- Data taken sporadically as detector cools
  - List of runs I have studied is at https://wiki.dunescience.org/wiki/ProtoDUNE_commissioning_runs_(dla)
  - Please let me know if I have missed anything interesting
- Tracks evident and plentiful with field on
  - See following displays
  - LAr is still dirty and so we only expect to see tracks very close to anode
    - By (my) eye, electron "lifetime" is 10 - 20 cm
- Noisy channels
  - Dominant feature of event displays
  - Presumably dominate the ROIs (recob::Wire) output by dataprep
  - Complicate studies of noise in quieter channels

Detector displays

Standard detector display

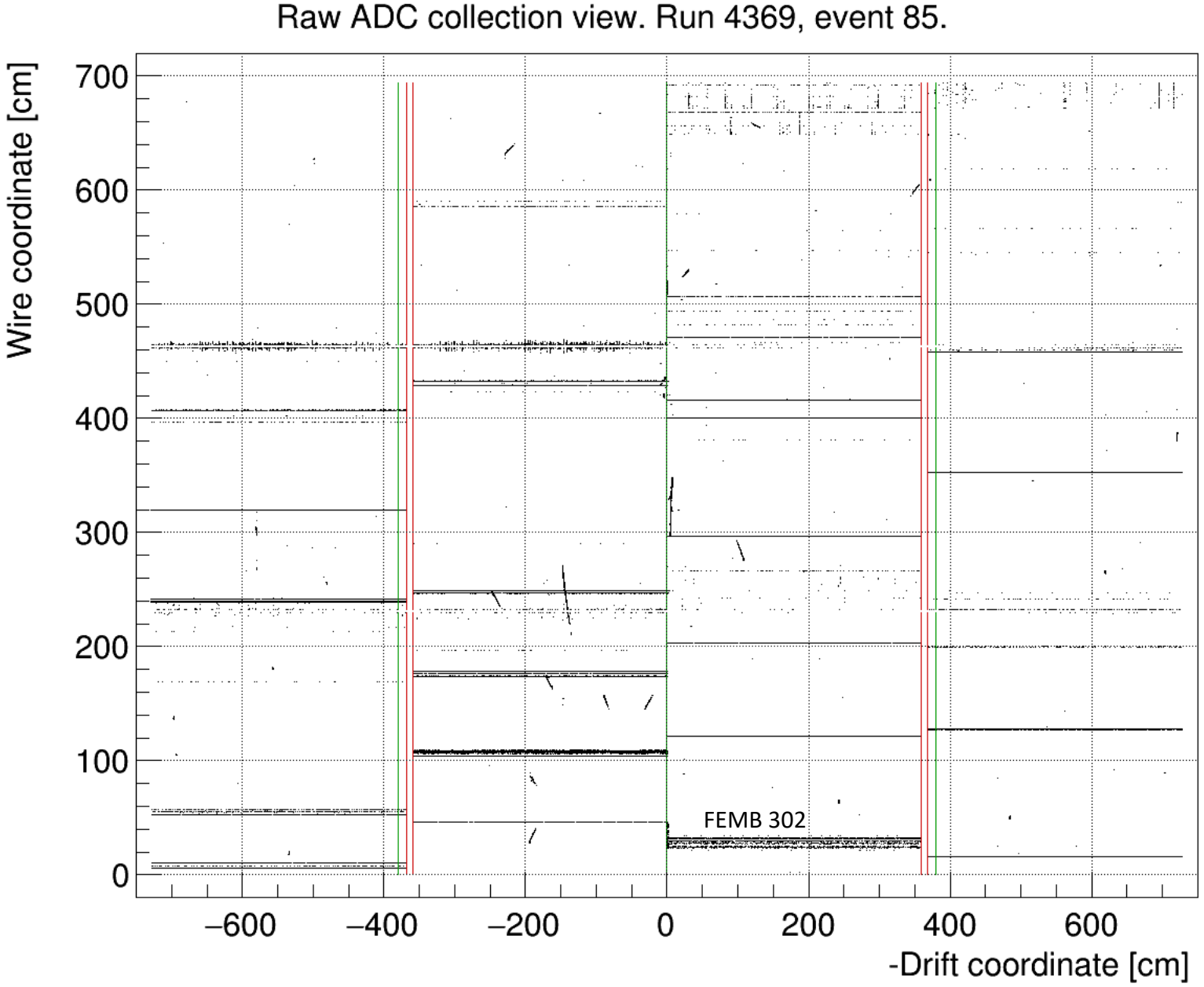
- Following page has standard detector display
  - Actual detector sensitive volume is shown
  - For run at 170 kV: tracks (and noise) are evident
  - Y-axis is channel number—beam runs bottom to top
  - X-axis is the drift coordinate
    - Reversed so right side is beam right
  - Threshold to display a channel-tick is 20 ADC counts (5X noise level)
  - Note that graph rather than histo is displayed so nothing is hidden
- Drift coordinate requires conversion from ticks
  - I.e. we need tick0 (tick to place at the anode) and drift speed
    - Here t0 = 0 and speed is 0.08 cm/tick (1.6 mm/μs)
  - Center of plot is populated by both right and left APAs
    - Because we read out more than on drift length
    - Maybe later suppress ticks beyond the cathode plane
  - We can set tick0 to put one track at the right position
    - Soon switch to 500 to correspond to trigger
    - Now trigger is random or anyways we don't expect to see the beam tracks

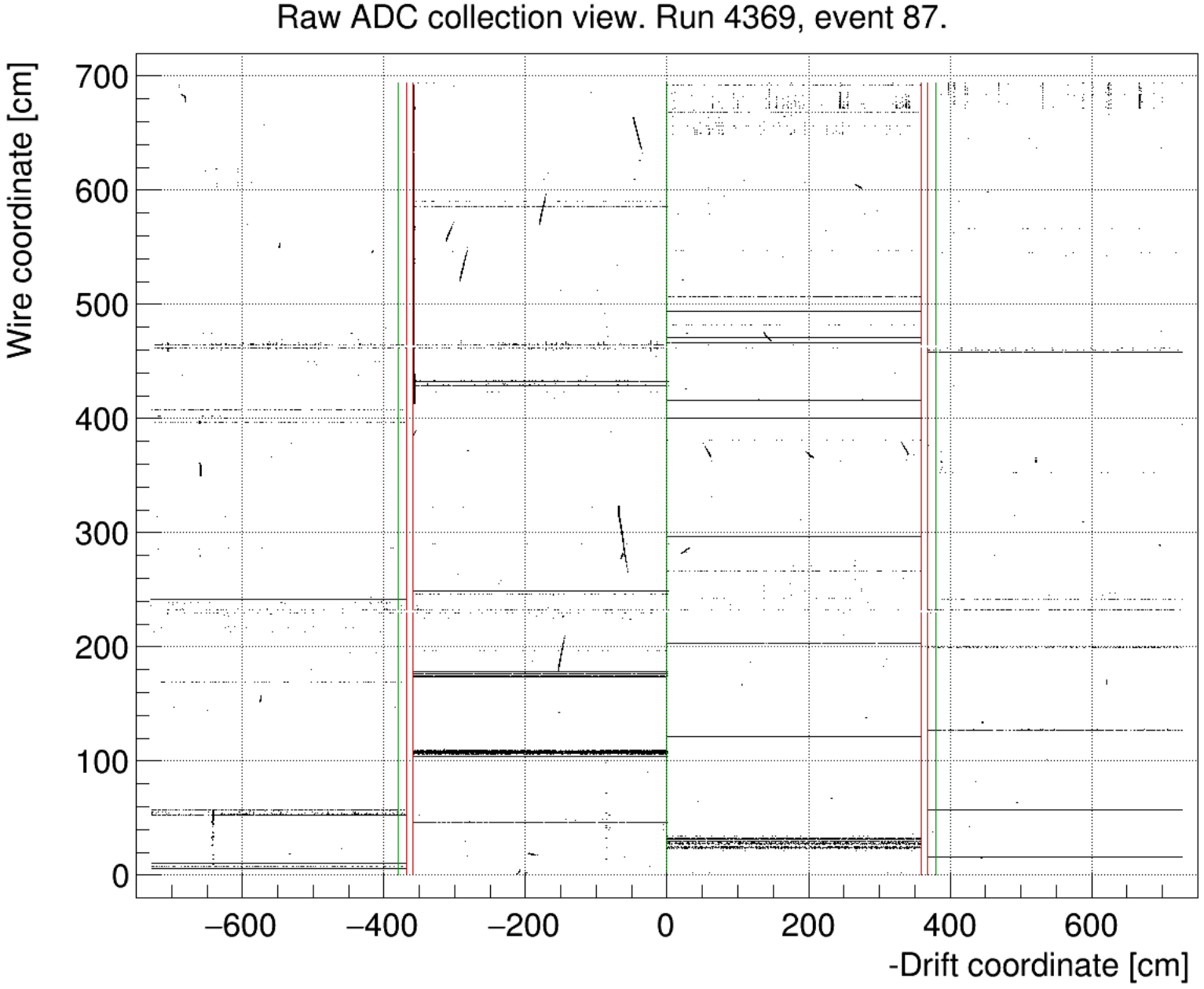

Raw ADC collection view. Run 4369, event 85.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−400
−300
−200
−100
0
100
200
300
400
-Drift coordinate [cm]

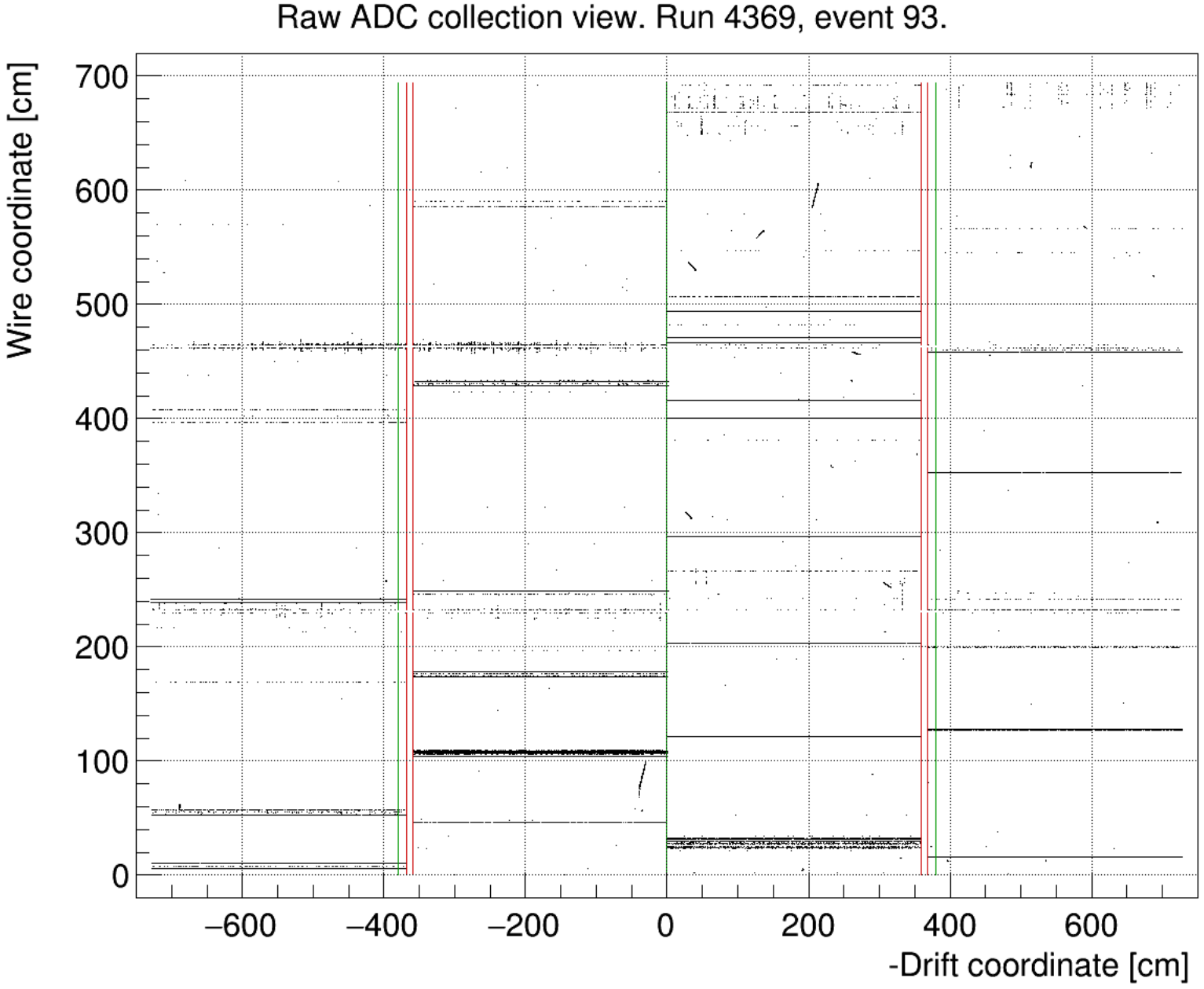
Detector displays (2)

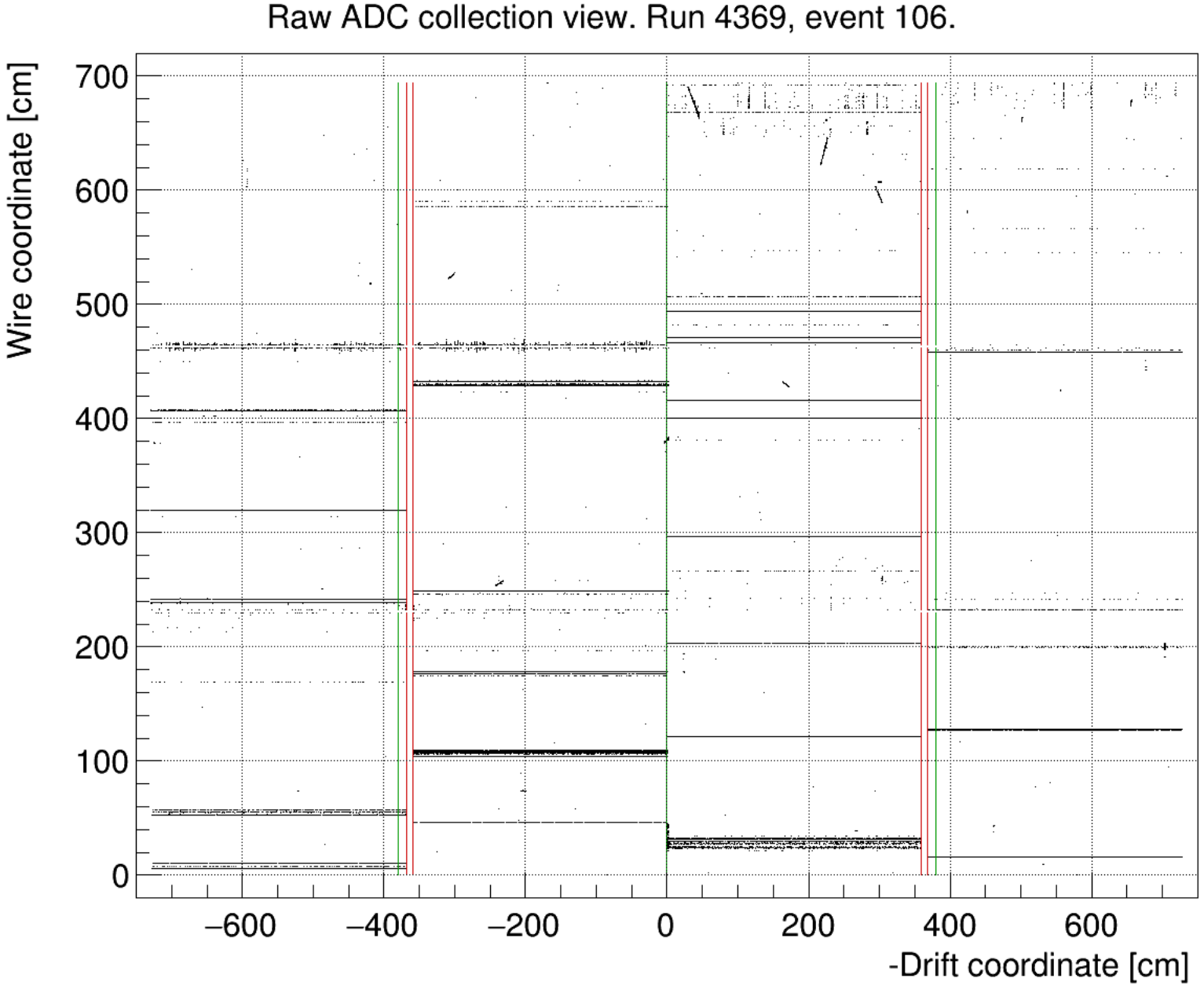
Expanded detector display

- To study noise, we would like to
  - See all channels and ticks including the cryostat-side planes
  - Avoid overlap between left and right APAs
- Following pages show examples of “expanded display”
  - Tick0 fixed to zero so data starts at APA plane
  - Drift speed reduced to 0.06 mm/tick so data collected on the TPC side just fits in the TPC volume
    - BTW this is the right value for 200 V/cm (72 kV)
  - X-axis expanded beyond cryostat to show cryostat-side data
  - First plot is same event as for the standard display


Raw ADC collection view. Run 4369, event 85.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−600
−400
−200
0
200
400
600
-Drift coordinate [cm]
FEMB 302


Raw ADC collection view. Run 4369, event 87.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−600
−400
−200
0
200
400
600
-Drift coordinate [cm]


Raw ADC collection view. Run 4369, event 93.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−600
−400
−200
0
200
400
600
-Drift coordinate [cm]


Raw ADC collection view. Run 4369, event 106.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−600
−400
−200
0
200
400
600
-Drift coordinate [cm]

Noise campaign

Preceding plots show all the collection channels

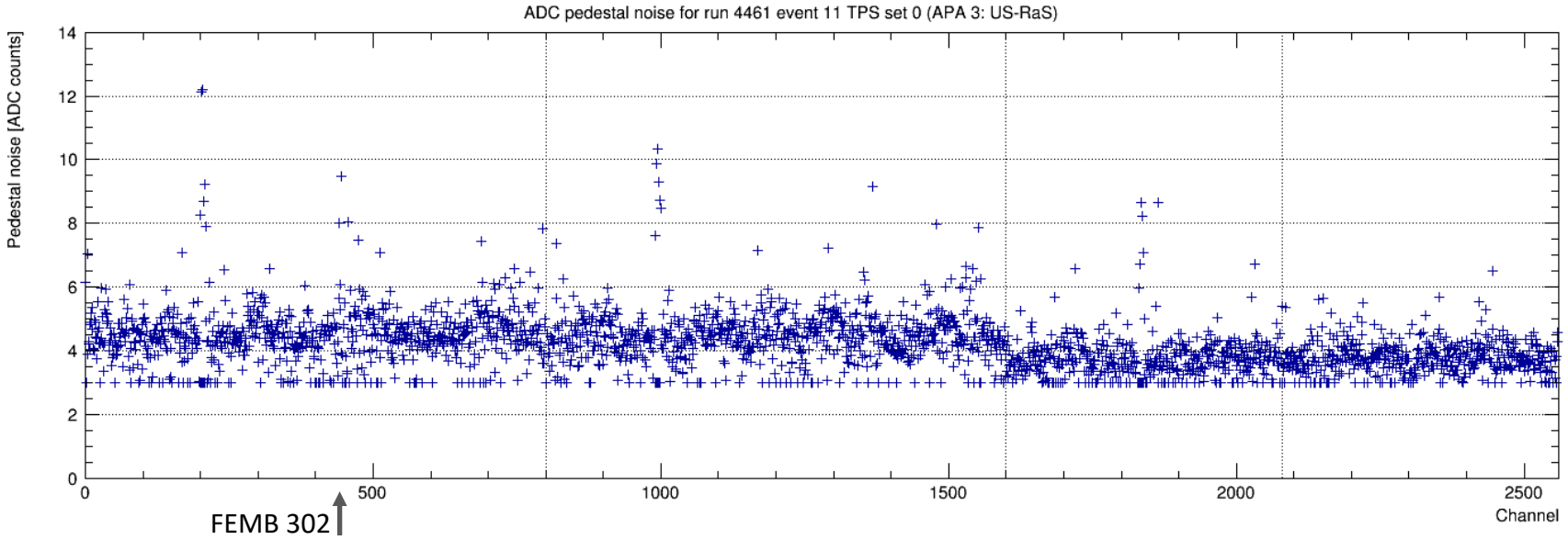
- A few hundred (of the 6k) have issues at the 5*noise level
- We would like identify these (channel, FEMB, …)
- And then flag as bad or mitigate noise
- And then do the same for the 9600 induction channels
  - Similar plots are available

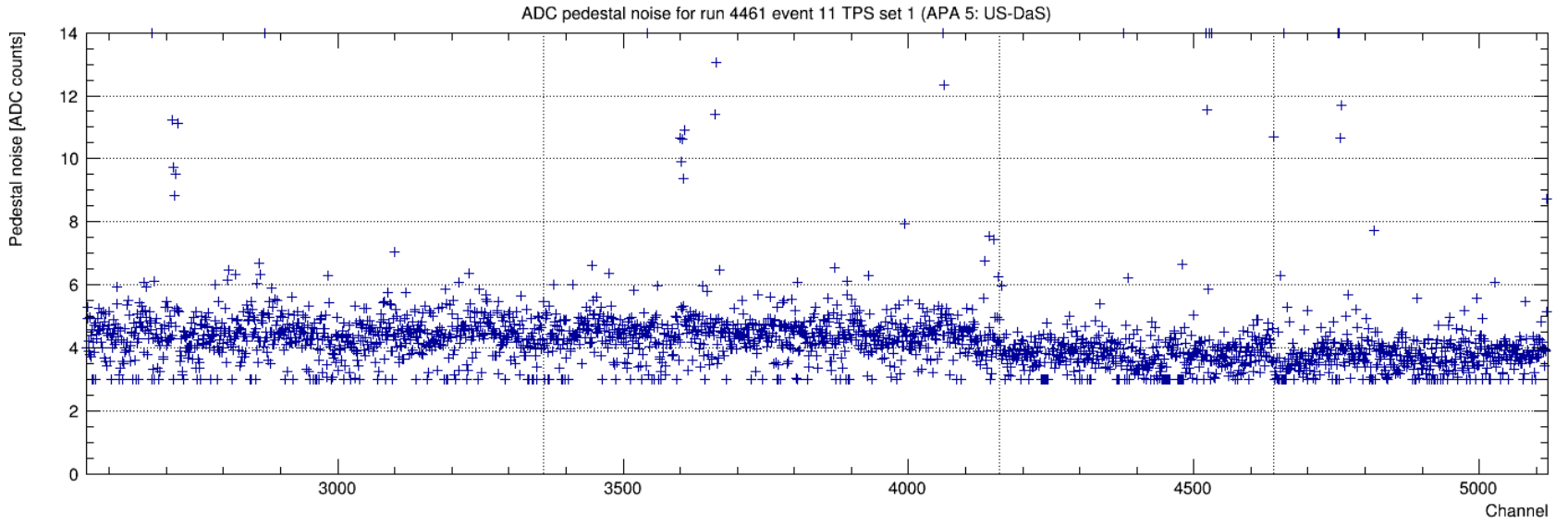
Identifying noisy channels

AdcChannelMetric tool has metrics for seeing noise

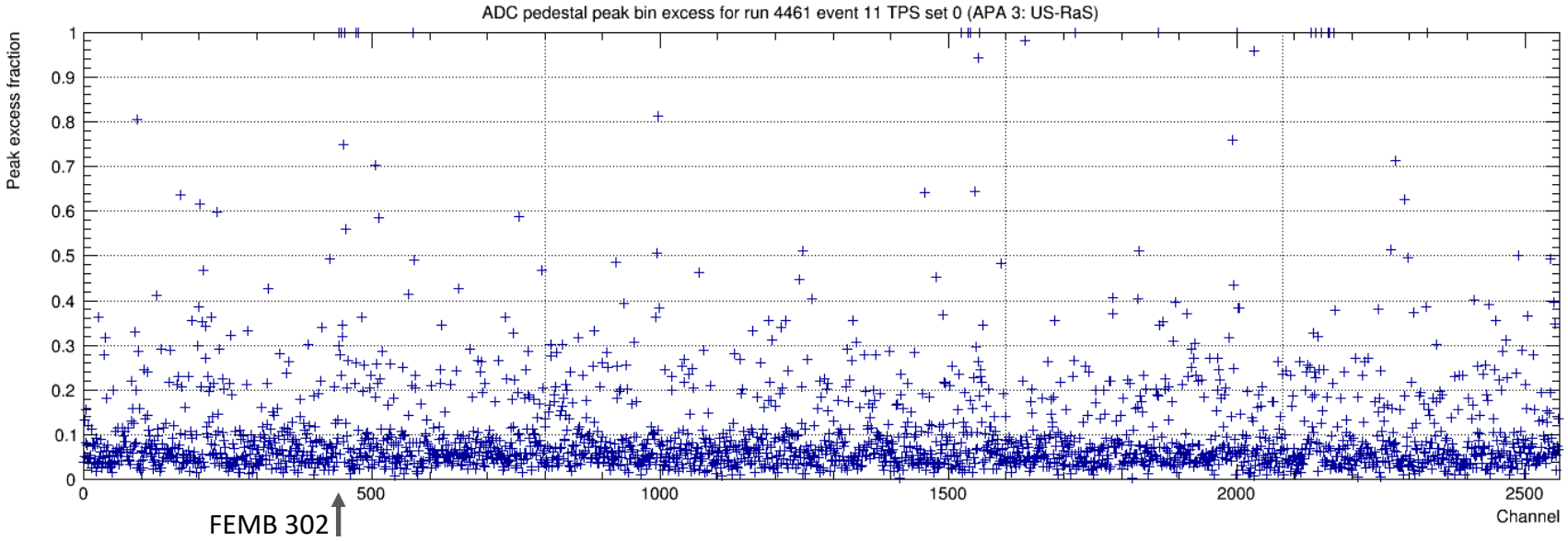
- Last week showed
  - Pedestal noise: Sigma of Gaussian fit to pedestal after removing one sticky code
  - Pedestal bin excess: Fraction of samples above fit in the sticky code bin
- Now add two more metrics
  - Raw RMS: RMS of raw ADC minus pedestal
  - Raw tail: Fraction of samples more than 3*noise away from the pedestal
- Examples of all of these follow
- New metric are more sensitive to the noise
  - Pedestal bin fraction may be large when sticky code is very close to the true value

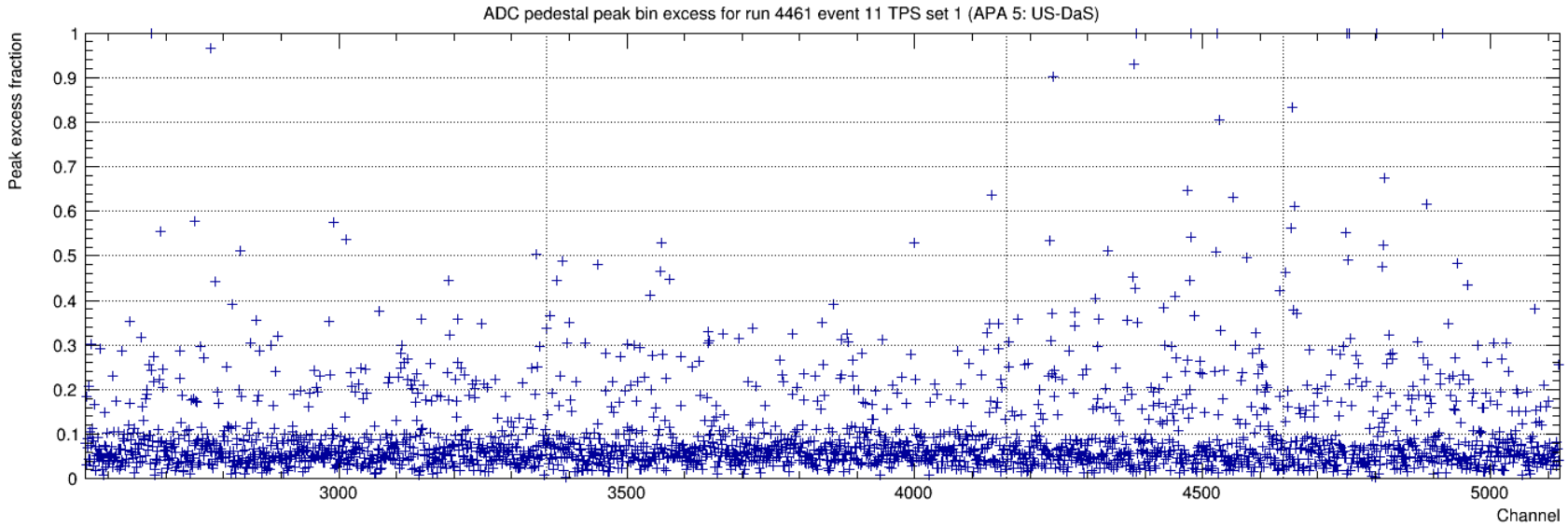
Pedestal noise



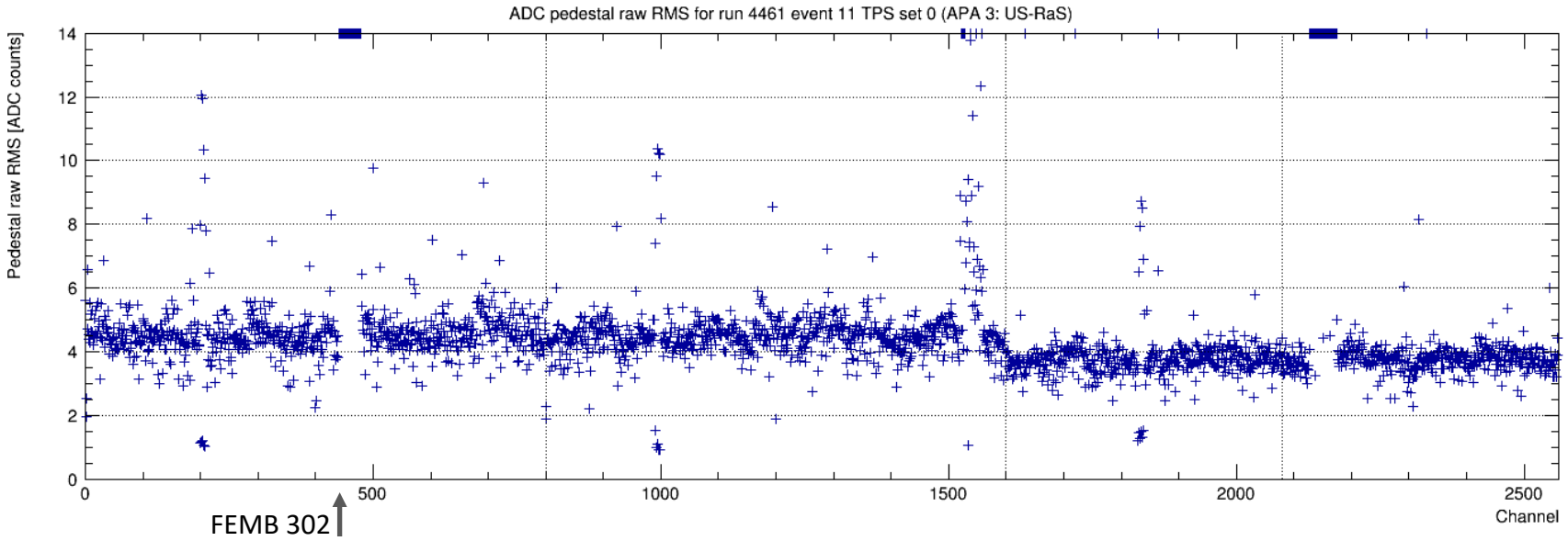


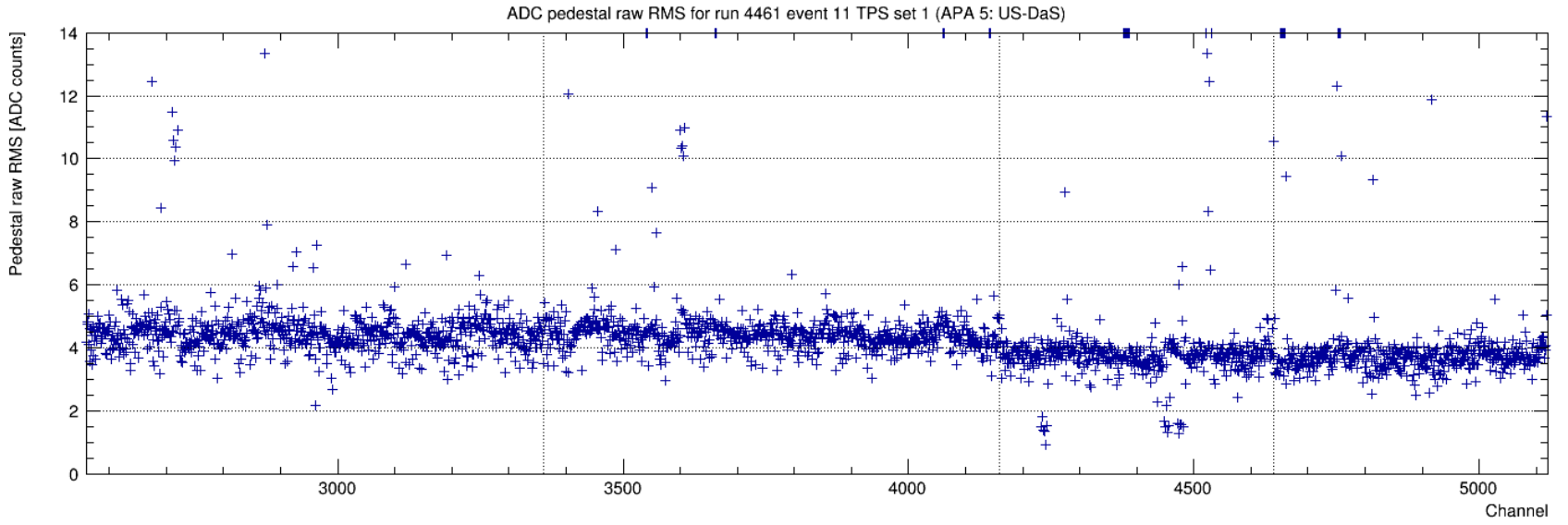
Pedestal bin excess



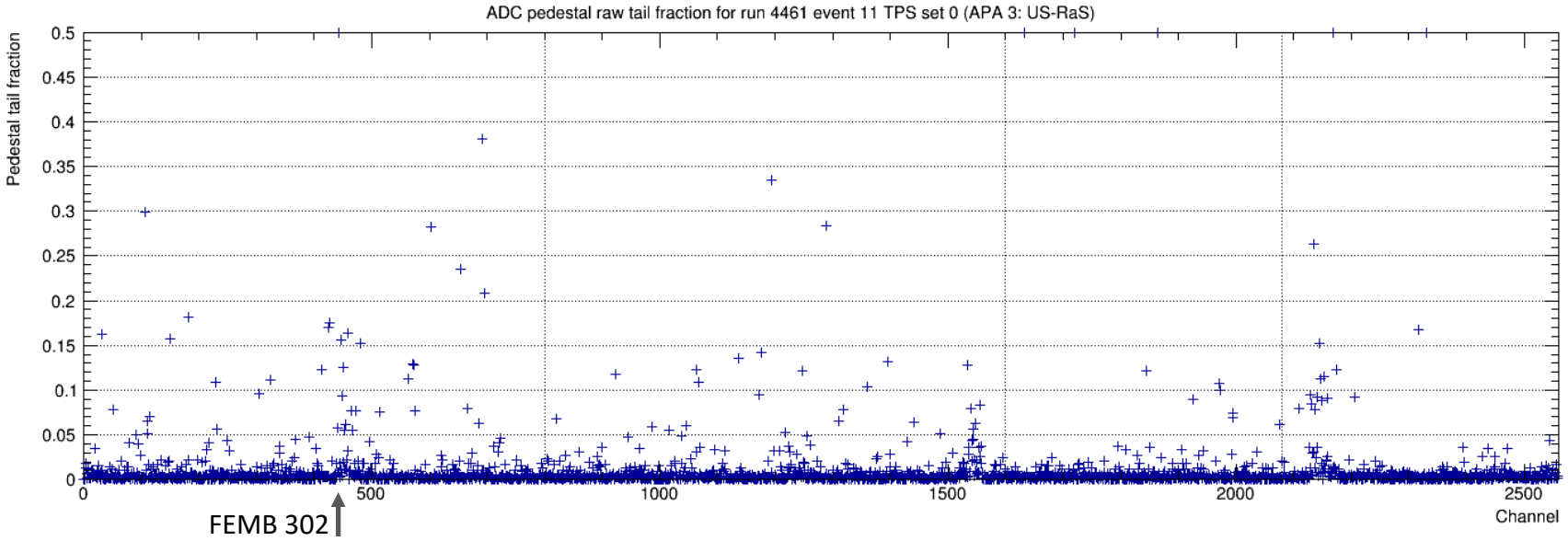


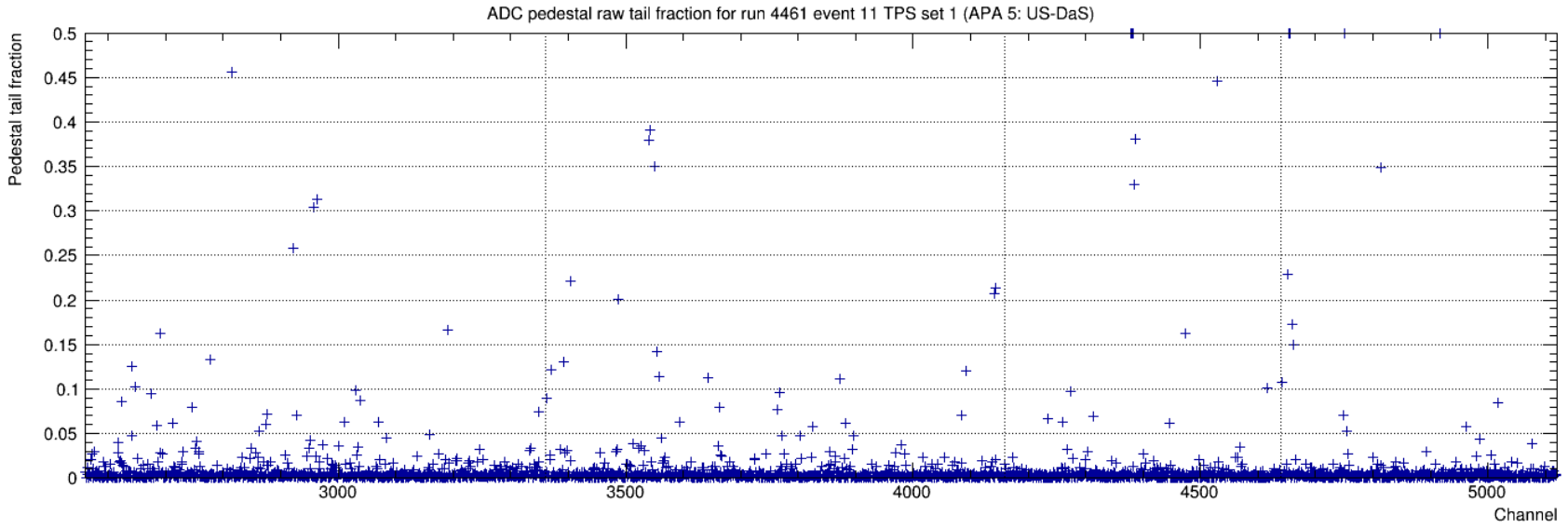
Raw RMS


ADC pedestal raw RMS for run 4461 event 11 TPS set 0 (APA 3: US-RaS)
Pedestal raw RMS [ADC counts]
0
2
4
6
8
10
12
14
0
500
1000
1500
2000
2500
Channel
FEMB 302


ADC pedestal raw RMS for run 4461 event 11 TPS set 1 (APA 5: US-DaS)
Pedestal raw RMS [ADC counts]
0
2
4
6
8
10
12
14
3000
3500
4000
4500
5000
Channel

Raw tail

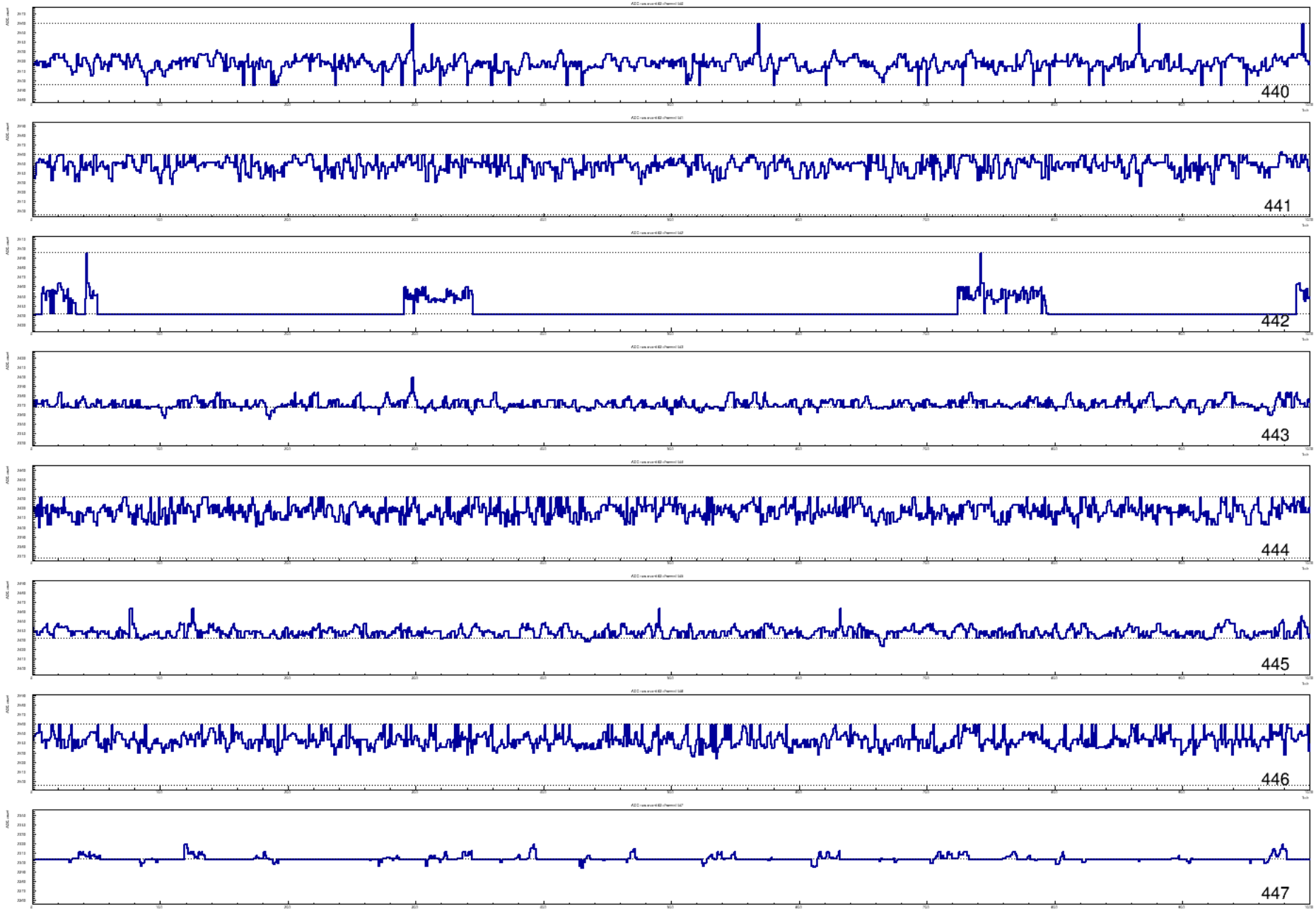

ADC pedestal raw tail fraction for run 4461 event 11 TPS set 0 (APA 3: US-RaS)
Pedestal tail fraction
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
500
1000
1500
2000
2500
Channel
FEMB 302

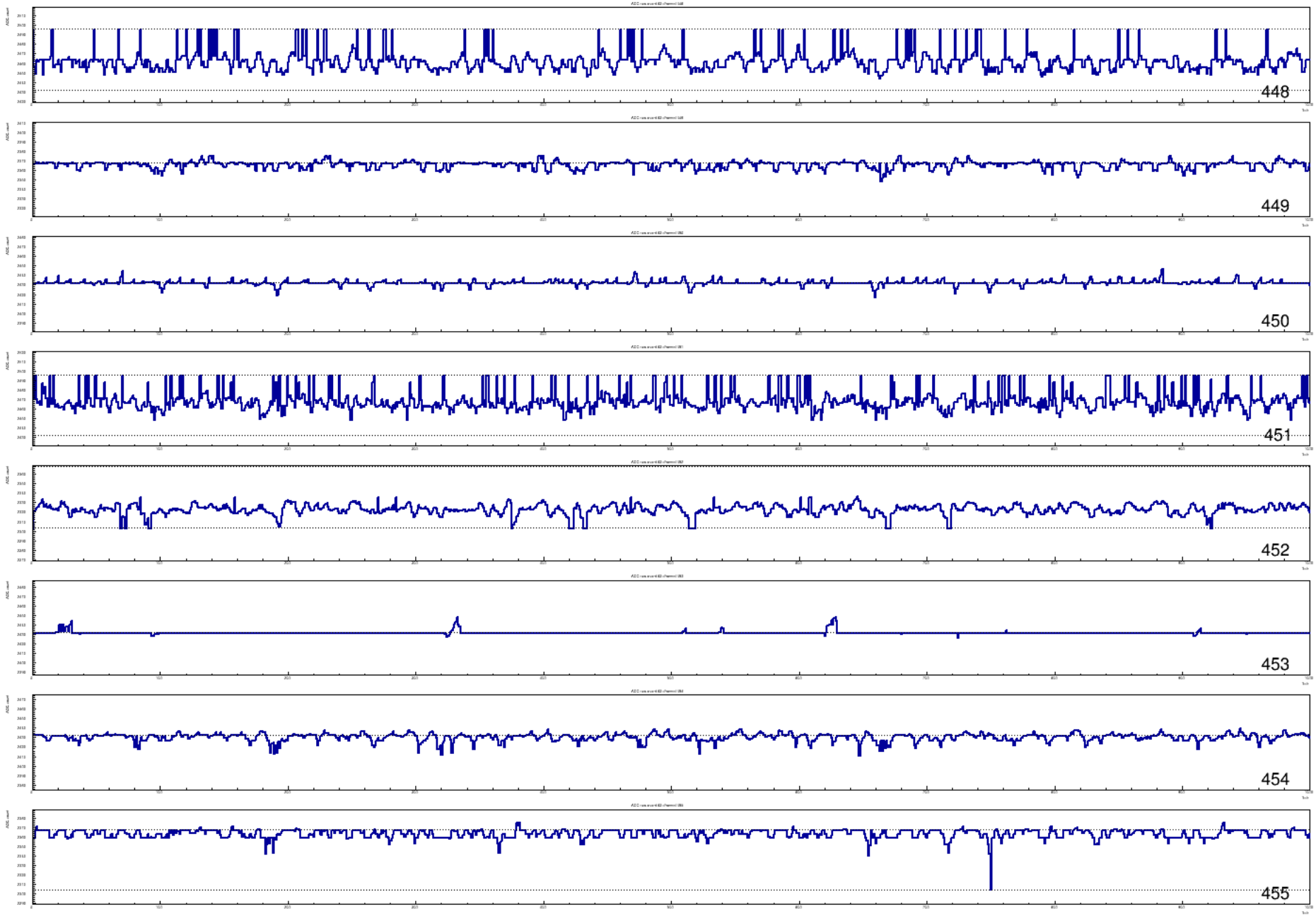

ADC pedestal raw tail fraction for run 4461 event 11 TPS set 1 (APA 5: US-DaS)
Pedestal tail fraction
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
3000
3500
4000
4500
5000
Channel

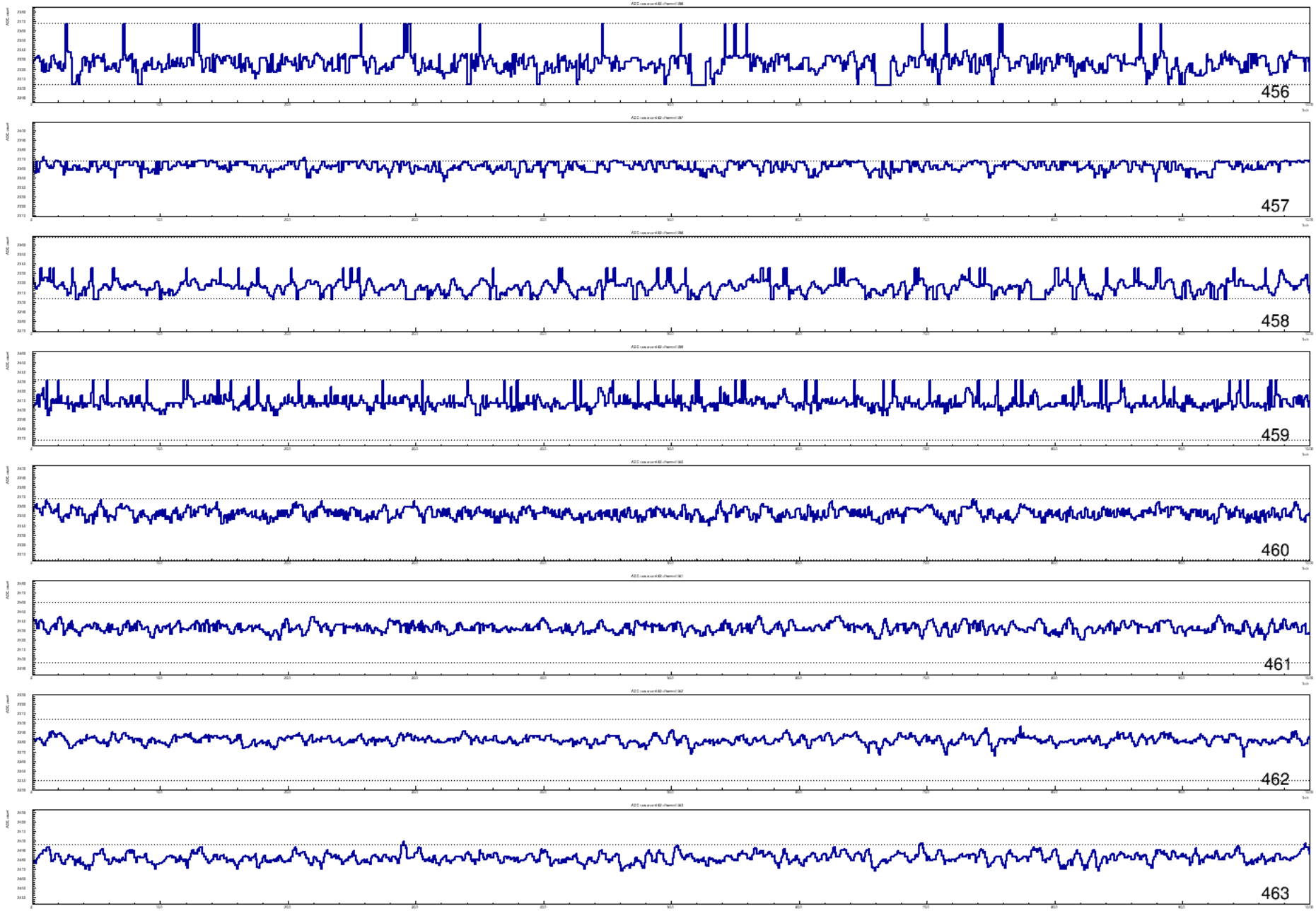
Waveforms

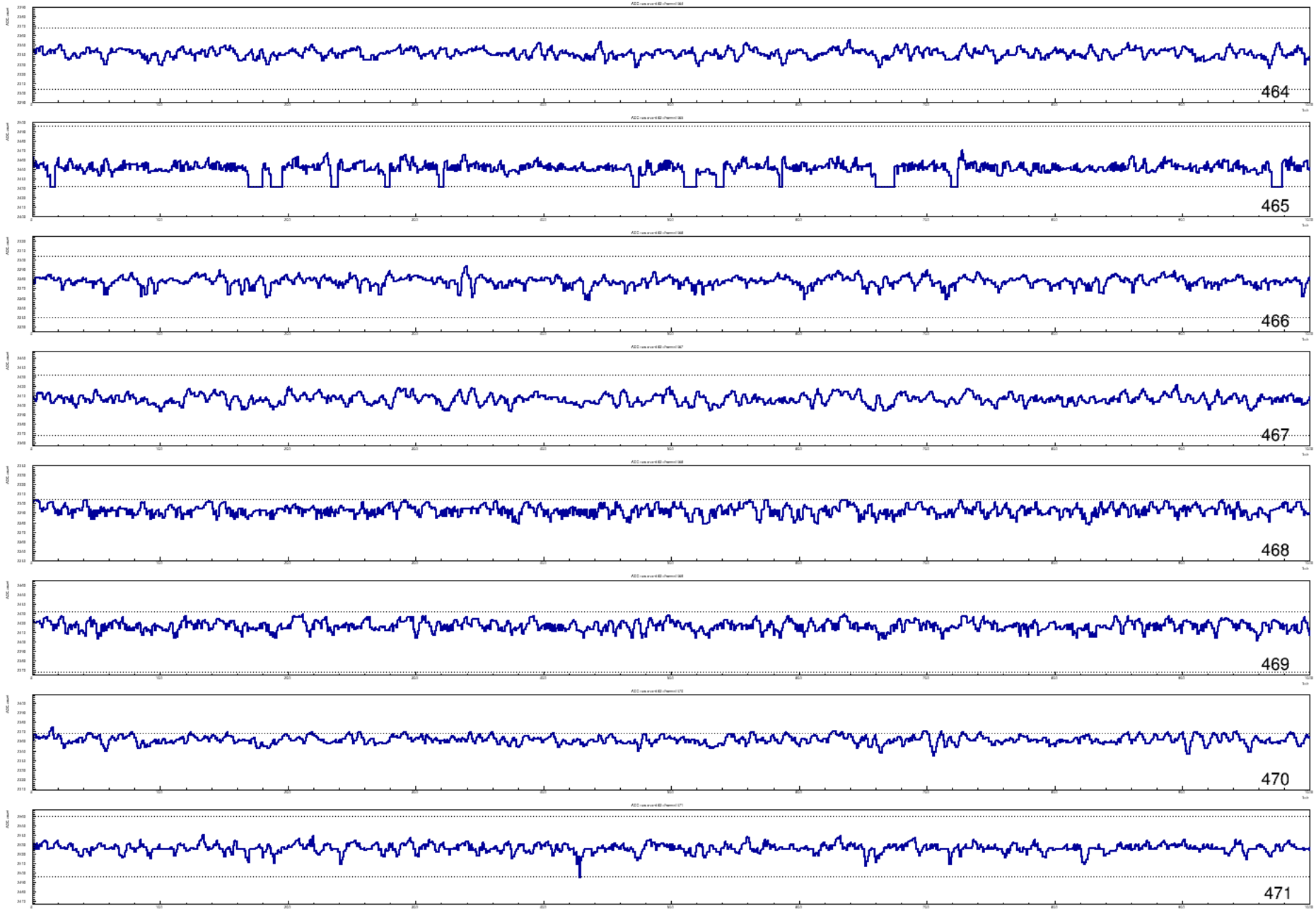
Once bad channels are identified…

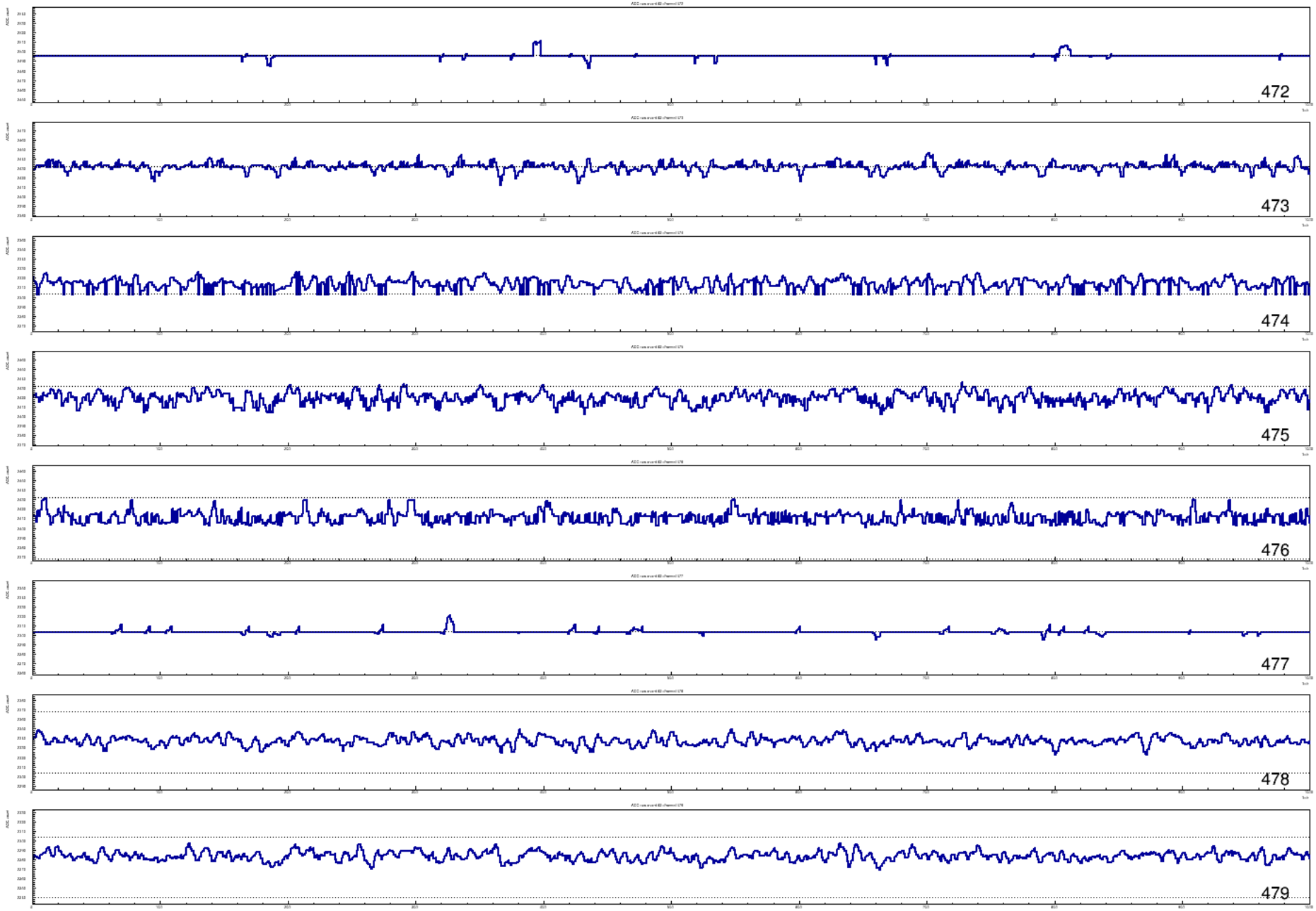
- Waveforms help us decide what the problem is
  - and what action to take
- Example waveforms from the troublesome FEMB 302 follow


440
441
442
443
444
445
446
447


448
449
450
451
452
453
454
455


456
457
458
459
460
461
462
463


464
465
466
467
468
469
470
471


472
473
474
475
476
477
478
479

Action

Deal with noisy channels

- Create bad channel list and skip those in processing
- Create list of sticky ADC channel/codes
  - Add tool to mitigate these with interpolation